DOUGLAS-FIR SEED DISPERSAL IN NORTHWESTERN CALIFORNIA

by Douglass F. Roy

PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
BERKELEY, CALIFORNIA

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FOREWORD

Since logging started in the Douglas-fir type of northwestern California, foresters have had little quantitative information on seed production and dispersal in that type. Here are the data from seed traps set out in four study areas during the years 1951 to 1958. They give foresters some direct evidence on which to base their plans for size of cutover, artificial regeneration, and cone collection. This report gives a complete analysis of the project and terminates this phase of the work.

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IN NORTHWESTERN CALIFORNIA

By Douglas F. Roy, Forester
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Seed production and dispersal are two of the most critical and salient factors affecting natural regeneration of forest trees. Since 1951 these subjects have been studied at four locations in the Douglas-fir type of northwestern California (fig. 1):

Slate Creek--a north-facing slope of 42 percent gradient at 2,600 to 3,400 feet above sea level.

Brush Mountain--two east-facing slopes with 34 and 46 percent gradients at 2,450 to 2,900 feet elevation.

Mill Creek--a north-facing slope of 8 percent gradient at 4,600 feet elevation.

Crew Property--a northeast-facing slope of 10 percent gradient at 800 feet elevation.

Data were obtained by counting and examining seeds caught in seed traps. At Slate Creek, Brush Mountain, and Mill Creek, the seed traps were placed on small clear-cut blocks and under adjacent reserved old-growth timber; at the Crew property, under residual trees left after partial cutting in young-growth timber. (Details about the study areas and procedures are given in Appendix A.)

These studies have contributed quantitative information concerning three major points: First, seed crops are variable and may be scanty for periods of several years. Second, seed crops generally are poor in quality. Third, amount of seed dispersed decreases rapidly with increased distance from the seed source.

Seedfall Variable and Often Inadequate

First, the study showed that Douglas-fir seed production is variable from year to year amd may be inadequate for several consecutive years. Isaac (1937) has estimated that 320,000 to 400,000 Douglas-fir seed ordinarily are required in the Pacific Northwest to seed a single acre of an area which has received no special treatments such as rodent control. This estimate seems high, but we can use it as a yardstick.

At Slate Creek, less than 52,000 sound seed per acre dropped on cutover blocks in 7 years (table 1). The greatest single year's seedfall on the cutover area was about 31,000 sound seed per acre in 1956. The 1957 crop was a complete failure.

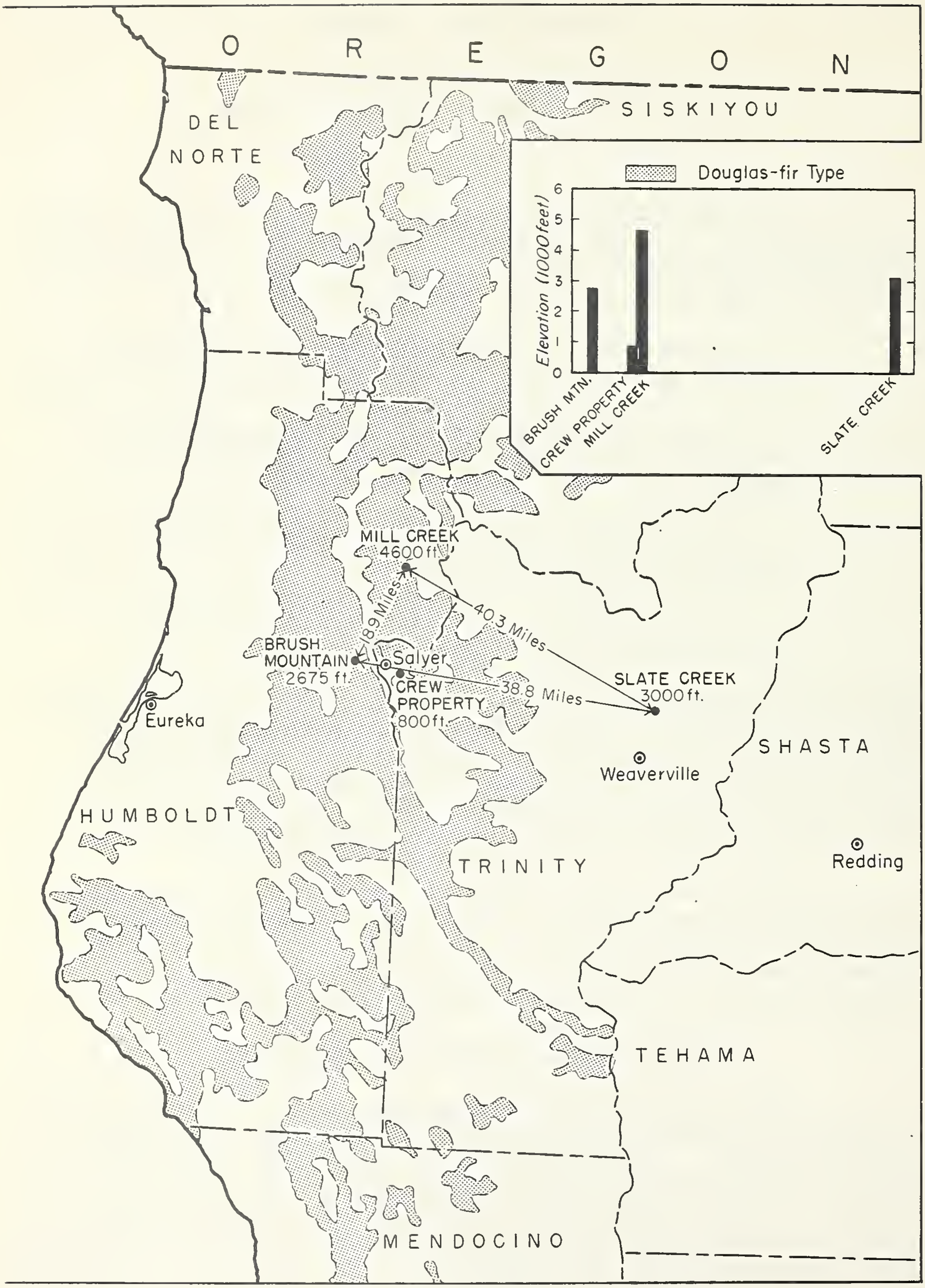

Figure 1.--Areas where Douglas-fir seed production and dispersal were sampled.

Table 1.--Sound Douglas-fir seed falling on clear-cut blocks, Slate Creek Unit, Trinity National Forest, 1951 to 1957

Year	Amount per acre	Sound seed total seed quotient	Basis, seed traps
	Number	Percent	Number
1951	283	53	150
1952	35	3	150
1953	1,308	17	138
1954	18,969	38	88
1955	531	2	30
1956	30,760	18	29
1957	0	0	30
Seven year total	51,886	15	

On Brush Mountain, Douglas-fir has produced seed more generously than at Slate Creek, but, by the Pacific Northwest standard, also in insufficient amounts. Seed traps caught about 122,000 sound seeds per acre in 5 years (table 2). For a single year, the smallest number of seeds distributed per acre over the cutovers was 300 in 1955, and the greatest number 89,000 in 1956.

Table 2.--Sound Douglas-fir seed falling on clear-cut blocks, Brush Mountain Unit, Six Rivers National Forest, 1953 to 1957

Year	Amount per acre	Sound seed total seed quotient	Basis, seed traps
	Number	Percent	Number
1953	13,112	19	130
1954	19,099	10	129
1955	300	1	124
1956	89,090	23	122
1957	131	(1/)	122
Five year total	121,732	18	

1/ Less than 0.5 percent.

At Mill Creek, the most abundant production of conifer seed occurred in 1953 when 92,920 Douglas-fir seed and 46,902 true fir seed were distributed per acre (table 3). The poorest seed year was 1957 when only 312 fir seed per acre were produced.

Table 3.--Sound seed falling on clear-cut block, Mill Creek Unit, Six Rivers National Forest, 1953 to 1957

Year	Douglas-fir		True firs		Basis, seed traps
	Amount per acre	Sound seed total: seed quotient	Amount per acre	Sound seed total: seed quotient	
	Number	Percent	Number	Percent	Number
1953	92,920	39	46,902	19	12
1954	996	7	0	0	16
1955	7,496	12	3,436	8	17
1956	8,745	21	7,809	8	17
1957	0	0	312	2	17
Five year total	110,157	26	58,459	12	

Seeds Generally Poor in Quality

In the 8 years, 1951-58, seed traps in northwestern California caught almost 42,000 Douglas-fir seeds, but their quality was discouragingly poor. All were examined by cutting tests. On the average only 18 percent were sound.

What are the reasons for bad seed? Some seeds are destroyed by insects. Damage by the Douglas-fir seed chalcid (*Megastigmus spermotrophus* Wachtl) can be identified easily by the characteristic small emergence holes in the seed coat or by the presence of larvae within the seed (fig. 2). Partially or completely pitch-filled seed are attributed to mining by larvae of three insects: the Douglas-fir cone moth (*Barbara colfaxiana* (Kearf.)), the fir cone-worm (*Dioryctria abietella* (D. & S.)) and, more rarely, the fir seed moth (*Laspeyresia bracteatana* (Fern.)). We should note, however, that seed traps do not sample certain insect-caused damage. The traps cannot catch the many seeds completely eaten by cone moth larvae, nor those destroyed by the gall midge (*Contarinia* sp.) which causes most of the affected seeds to adhere to the cone scales.

But most of the bad seed has been empty. These seeds generally have fully formed seed coats but contain only a wisp of dried white tissue, the inner integument, which, with the seed coat,

develops without seed fertilization. Embryos and endosperm are lacking. The problem, therefore, appears to originate from either a lack of pollination or fertilization.

Some seeds found in seed traps were broken and during the first years of this study, these seeds were believed to result from the feeding of white-footed mice (Peromyscus maniculatus) as they perched on the seed traps. Later, however, we recognized that empty seeds often have extremely thin and fragile seed coats which break at the lightest touch. They could easily fracture upon hitting the seed trap screens. Therefore, broken seeds were counted beginning in 1955. That year nearly 30 percent of the seeds were broken; in 1957, 10 percent.

At Slate Creek the highest proportion of sound seed was 50 percent in 1951, when seedfall was extremely scanty (table 4). The 1957 cone crop produced no sound seed. Even in 1956, the heaviest seed year of record, only 18 percent of the seed was sound. Good Douglas-fir seed amounted to only 15 percent of the total seeds caught in traps at Slate Creek in the 7 years, 1951-1957.

At Brush Mountain the highest quality seed lot (27 percent sound) was produced in 1956 (table 5). The 1955 and 1957 seed lots contained no sound seed. Only 18 percent of the seed caught on Brush Mountain in the period 1953 to 1958 was good.

At Mill Creek the percent of good Douglas-fir seed varied from 38 percent in 1953 to none in 1957 (table 6). And in the 5-year period 1953 to 1957, sound seed averaged 26 percent. The best true fir seed crop in this period was 22 percent sound (1953), and the worst yielded no good seed (1954 and 1957). For the 5 years, 15 percent of the true fir seeds were good.

The Crew Property had the best seed lot sampled during the study: in 1956 more than 41 percent of the seed was sound (table 7). Most of the good seed fell before November 3, 1956, but 9 percent was released after March 19, 1957:

Collection date	Sound seed per acre: Number	Sound seed per acre: Percent
Nov. 3, 1956	275,514	85.1
Mar. 19, 1957	18,289	5.6
June 28, 1957	30,088	9.3
All	323,891	100.0

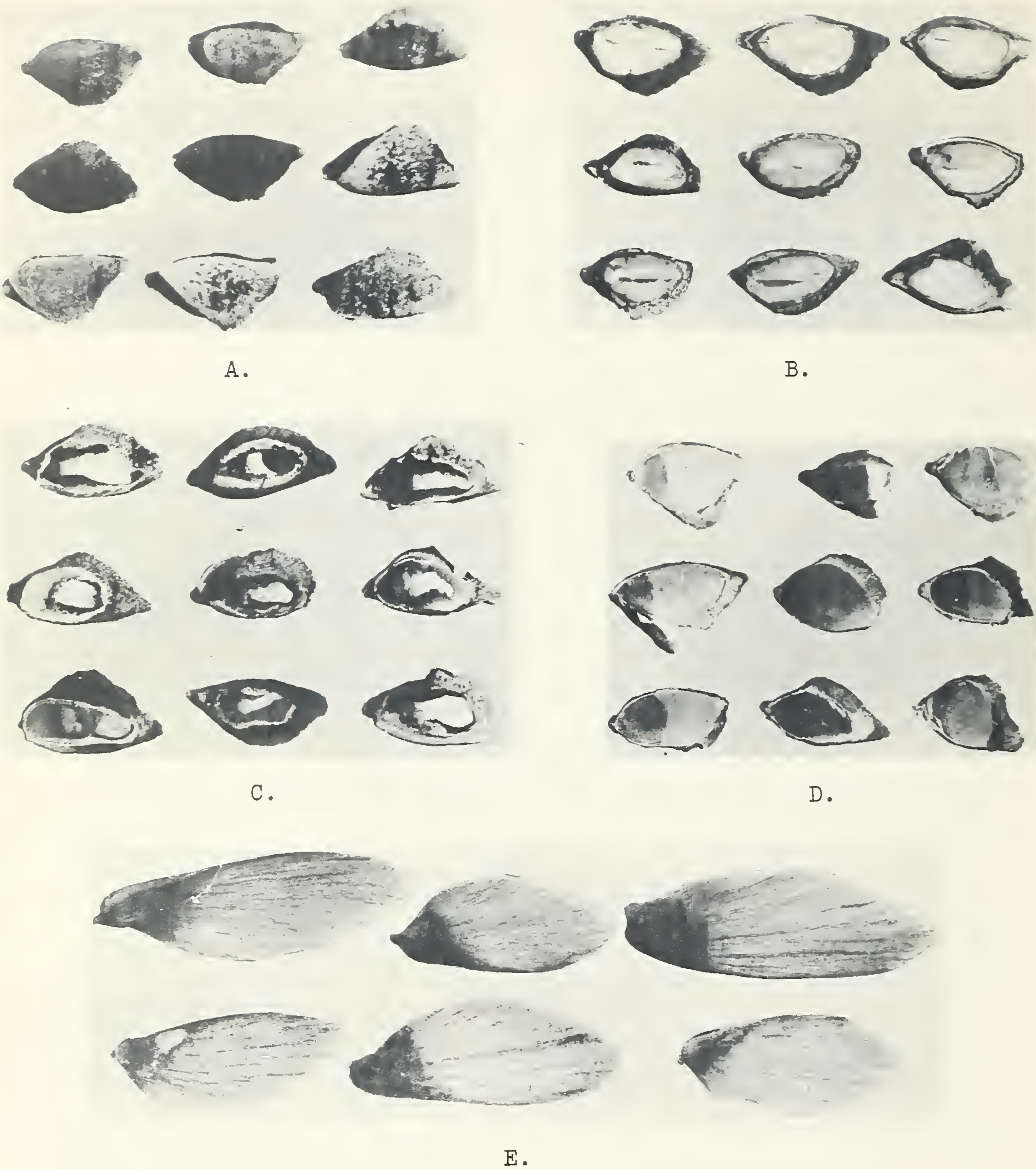

Figure 2.--Douglas-fir seed conditions. A. External view of sound seeds. Ventral (cone-scale side) surface light colored. B. Sound seeds cut open to expose endosperms and fully-developed embryos. C. Empty seeds cut open to show shriveled inner integument. D. Large fragments of broken seeds. E. Aborted seeds.

F.

G.

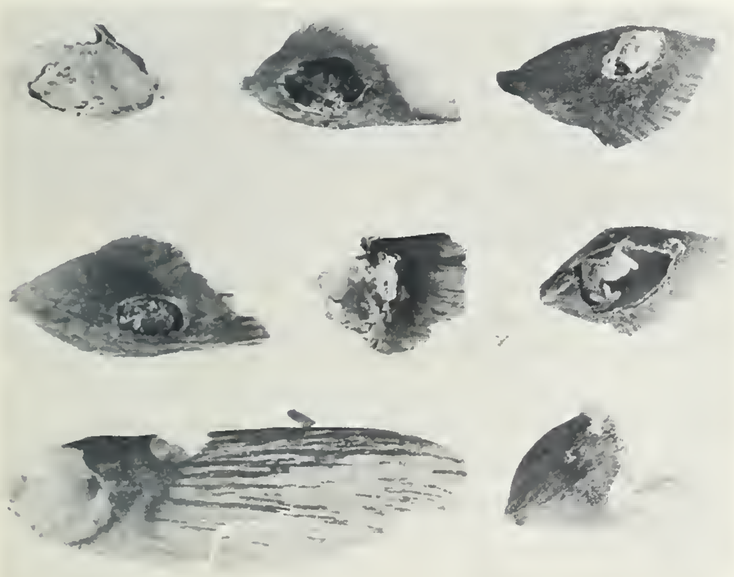

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Figure 2.--Douglas-fir seed conditions - continued. F. Seeds cut open to show larvae of the Douglas-fir seed chalcid. G. Seeds showing the characteristic emergence holes bored by the Douglas-fir seed chalcid. H. Pitch filled seeds caused by larvae of the Douglas-fir cone moth, the fir coneworm, or the fir seed moth. I. Cone scales with seeds adhering, a result of work by the gall midge.

In the bumper seed year of 1956, the seed traps in all study areas caught 20,620 seeds. Of these 23 percent were sound, but two-thirds were empty:

Condition of seed:	Percent
Sound	23
Unsound	
Damaged by insects	
Chalcid	1
Pitchy	3
Total	4
Other bad seed	
Empty	67
Aborted	6
Total	73

This large amount of empty seeds indicates a problem which may become extremely serious in the management of seed collection areas or seed orchards in northwestern California.

A similar problem has been recognized elsewhere. In Finland, Sarvas (1955) attributed empty seeds from birch, pine, spruce, and larch to incomplete pollination. In Colorado, Roeser (1942) studied the influence of climate on seed production of Douglas-fir and concluded that the chance of pollination failure because of lack of pollen is small, but he recognized that incomplete pollination may be associated with wet weather.

Seed Dispersal Decreases Rapidly With Distance From Seed Source

Seeds falling from the timbered borders do not fall evenly over clear-cut blocks. Many other workers have demonstrated this fact for Douglas-fir and other species. Isaac (1930), in a study using very few seed traps, caught only 37 percent of the under-timber seedfall in traps placed 100 and 200 feet from a stand of Douglas-fir. Clark (1958) investigated seed dispersal from an open Douglas-fir stand and estimated that 87 percent of the sound seed fell within 1 chain of its source. Results from study of other species differ in details but support the general conclusion; these studies include investigations of lodgepole pine (Boe, 1956), longleaf pine (Boyer, 1956), and black spruce (LeBarron, 1939 and 1948).

In our northwestern California study, the number of sound seed delivered to the ground decreased rapidly with increasing distance from the seed source (tables 8 and 9). The amounts of seed falling on the centers of clear-cut blocks--areas 5 to 6 chains away from timber--varied from 0 to 16 percent and averaged 10 percent of the seedfall under trees adjacent to the cutover.

Here is a clue for determining the maximum size of clear-cut blocks. Their width must be limited if the land manager plans to

restock them naturally. A maximum width of 8 chains is recommended.

One way to evaluate seedfall is to express the amount of sound seed falling at given distances from the timber edge as a percent of the "under-tree seedfall." Under-tree seedfall is defined as the amount of sound seed falling on the zone 1 to 2 chains within the timber stand surrounding the clear-cut block. Data computed in this way were plotted for the Slate Creek seed crops of 1954 to 1956, and for Brush Mountain 1953 to 1957. These data also were weighted and averaged, and an average curve was plotted (fig. 3). Points plotted for the scantiest seed crop (Brush Mountain 1957) were widely dispersed, those for the heaviest seedfall (Brush Mountain 1956) conformed most closely to the average curve.

Some foresters may be surprised to see that the average seed dispersal curve shows a drastic decrease in seedfall within the timber stand as we move toward the cutting boundary. A diagram (fig. 4) can explain this decrease. In the diagram the width and length of crowns and the heights of the trees are proportionately accurate. If we assume most of the seeds will fall under a tree on the base of a cone truncated by the lower crown, the sketch shows that the full seed-production effect of the stand is not reached until well within the forest.

Another surprise is the distribution of empty seeds. Most of us intuitively would think empty seeds fly farther than sound seed. We would assume the ratio of sound seed to total seedfall would decrease with distance from the trees. Within the limits of this study the assumption is not true. The distribution of good, insect-destroyed, aborted, or empty seeds was nearly the same regardless of the distance from timber (table 10).

This distribution is strong evidence that dispersal of seed over cutting blocks of the size studied is dependent upon the pattern of gentle and strong winds and not upon the aerodynamic characteristics of seeds. The curve of seed dispersal (fig. 3), which declines steeply from the timber edge toward the center of cutover blocks, suggests that most seeds fell during periods of no wind or of gentle breezes. If most seeds were dispersed by strong winds the curve representing seedfall would be lifted toward a horizontal position.

In the South, Boyer (1958) found the soundness of longleaf pine seed shed on a clear-cut area decreased significantly with distance from the forest wall, and also with passage of time. In the Pacific Northwest, Isaac (1930) released Douglas-fir seed from a kite flying in a strong wind. The percent of sound seed was normal for the lot at the place where heaviest fall occurred; between that point and the point of release the percent of sound seed was above normal, and beyond that place was below normal for the lot.

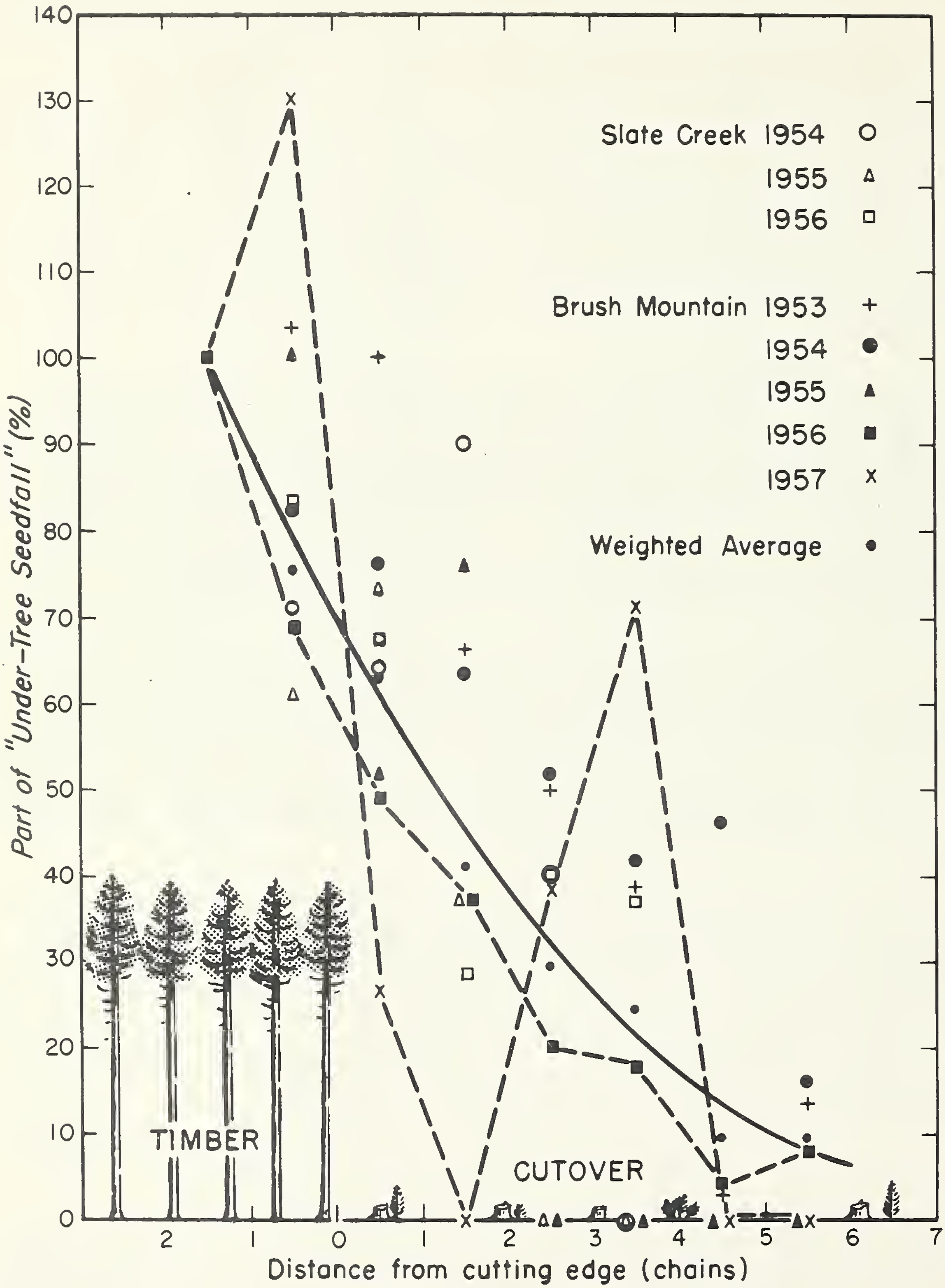

Figure 3.--Dispersal of Douglas-fir seed.

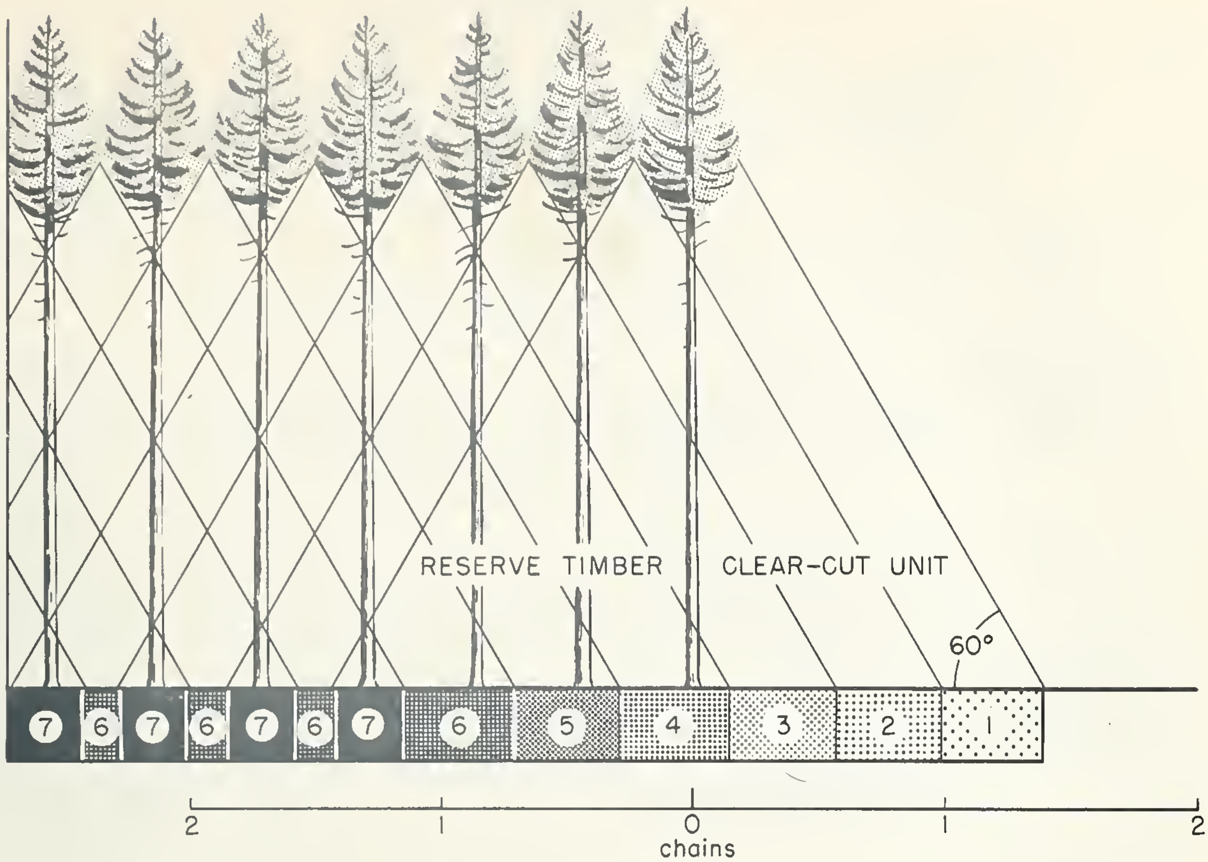

Figure 4.--Diagram of transect perpendicular to cutting edge of clear-cut block. Numbers at the base of diagram indicate the number of trees contributing the major amount of seed within each zone. (Scale for Site II.)

Conclusion

The information from this study in northwestern California will help foresters or land managers plan logging patterns and regeneration activities. For example, the striking pattern of seed dispersal as related to distance from the seed source should be considered when laying out clear-cut units for natural reproduction. Eight chains look like the practical limit for width of cut blocks.

The irregular seed crops mean we cannot expect to obtain adequate natural reproduction every year. In fact, the majority of areas logged in California in the Douglas-fir type probably will need artificial restocking. The prevailing seed production characteristic of Douglas-fir stands in California--scanty production of sound seeds-- suggests two ideas: the need to establish seed banks, and to estimate cone collection goals accurately.

The occasional bumper seed crop must be capitalized by collecting enough seed to bridge the gap of lean years. The soundness of seed in a Douglas-fir cone crop should be determined immediately before collection. With this information the forester can estimate accurately the quantity of cones which will yield the sound seed required for his operation.

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APPENDIX A

STUDY AREAS AND PROCEDURES

Study Areas

Slate Creek

The first study area was the Slate Creek Unit, Trinity National Forest, located 7 miles north and slightly east of Weaverville, Trinity County. This unit, consisting of 5 clear-cut blocks ranging in size from 3.3 to 11.8 acres, was laid out almost entirely on a north-facing aspect having an average slope of 42 percent. Elevations ranged between 2,600 and 3,400 feet.

The individual blocks, alternating with reserved stands of mature timber, were logged in the fall of 1950 and spring of 1951. Composition of the stand by volume was: Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) 84 percent; white fir (*Abies concolor* (Gord. & Glend.) Lindl.) 8 percent; sugar pine (*Pinus lambertiana* Dougl.) 6 percent; and ponderosa pine (*P. ponderosa* Laws.) 2 percent; with a nominal amount of incense-cedar (*Libocedrus decurrens* Torr.).

Brush Mountain

The second study area was in the Brush Mountain Unit, Six Rivers National Forest, and included Block A, of 14.2 acres and Block D, 13.3 acres. This unit lies on east-facing terrain approximately 4 miles west of Salyer, California. It was logged in clear-cut blocks between April 21 and August 31, 1952. The ground is moderately steep, Blocks A and D sloping 34 and 46 percent, respectively, and elevations range between 2,450 and 2,900 feet.

The timber stand was essentially pure Douglas-fir, with occasional hardwoods. Both blocks are bordered by reserved stands of mature timber, except for the lower edge of Block A which adjoins older cutover land.

Mill Creek

The Mill Creek Unit, Six Rivers National Forest, is situated at relatively high elevation (4,600 feet), but on a gentle (8 percent) north-facing slope. The study area, approximately 11.2 acres in size, was a single block clear-cut in 1948 in a mature stand of Douglas-fir and firs, including white fir, noble fir (*Abies procera* Rehd.), and Shasta red fir (*A. magnifica* var. *Shastensis* Lemm.).

Crew Property

The fourth study area was 1.3 acres of the Crew property about 2 1/2 miles east and 1 mile south of Salyer. Here seed traps were distributed under a stand of young-growth Douglas-fir about 80 years old, which had been subjected to partial cutting. This stand averaged 36 stems and 20,013 board feet to the acre. The average dominant tree was 24.4 inches in diameter and contained 746 board feet. The ground slopes toward the northeast at 10 percent, and the elevation is about 800 feet.

Procedure

At Slate Creek, Brush Mountain, and Mill Creek, seed traps were placed to sample seedfall both on the cutover blocks and under the adjacent timber stands. The traps were the standard size commonly used in California which have effective areas of 8.2 square feet. Traps were arranged in two transects at right angles to each other at Slate Creek (fig. 5). Multiple transects were used at Brush Mountain (fig. 6). At Mill Creek and on the Crew property traps were distributed randomly.

Seeds were collected from traps each year in June at Slate Creek, Brush Mountain, and Mill Creek. Traps were in place on the Crew property during only one seedfall, the bumper crop of 1956. These traps were emptied on November 3, 1956, and on March 19 and June 28, 1957.

All seeds collected were cut to determine soundness, and counted. Records were kept by individual seed traps so data could be stratified by distances the traps were placed from cutting borders.

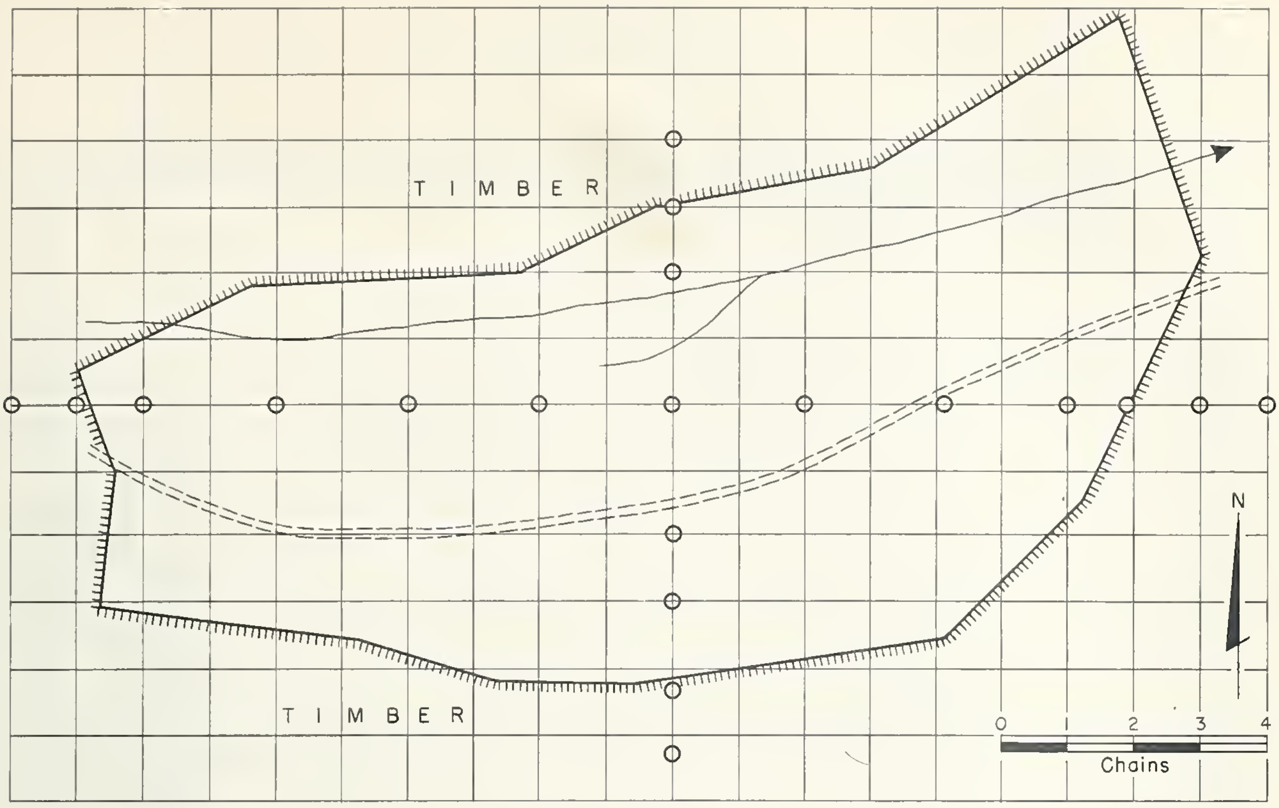

Figure 5.--Seed trap locations on Slate Creek Unit Block 1, Trinity National Forest, 1954-1958.

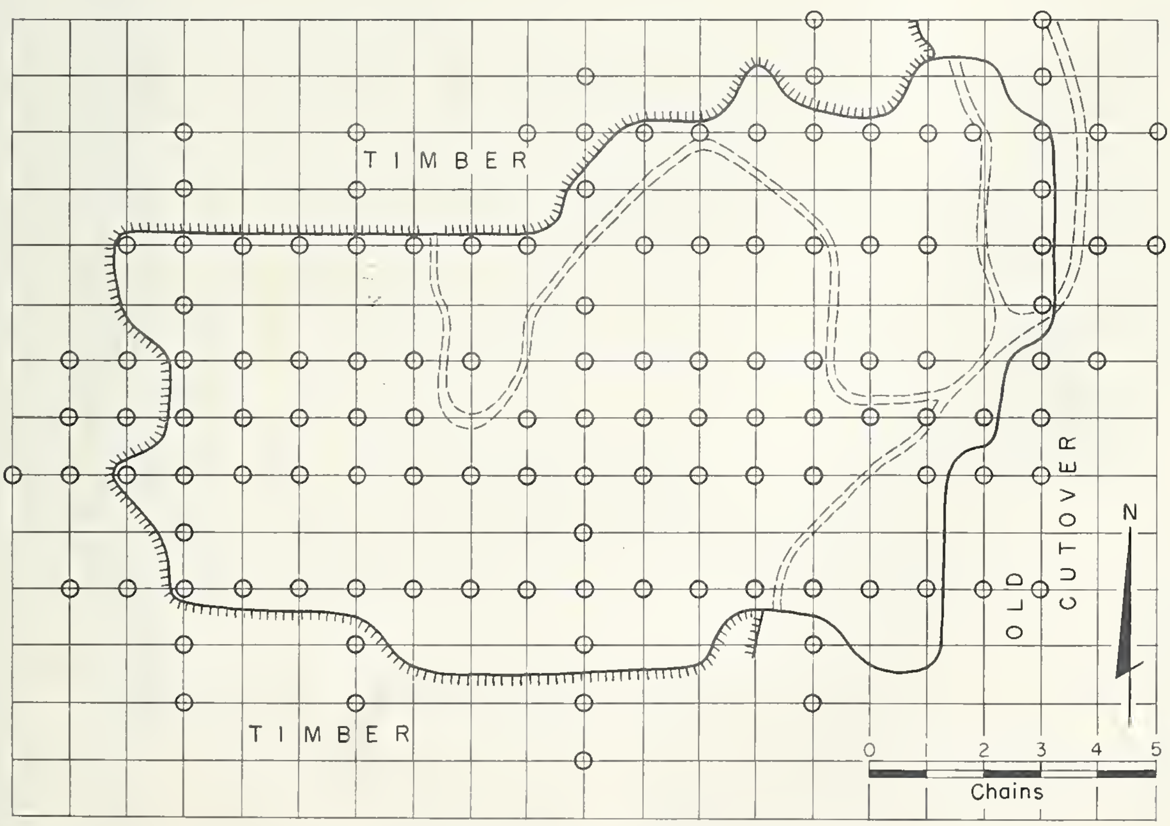

Figure 6.--Seed trap locations on Brush Mountain Unit Block A, Six Rivers National Forest, 1952-1958.

APPENDIX B

DETAILED TABLES

Table 4.--Condition of Douglas-fir seed falling on clear-cut blocks and under timbered borders, Slate Creek Unit, Trinity National Forest, 1951-1957

Seed condition	1951	1952	1953	1954	1955	1956	1957	All
	Percent							
Sound	50.0	3.2	16.6	25.6	1.9	17.8	0.0	14.5
Germinated	--	--	--	--	--	5.4	--	--
Other	--	--	--	--	--	12.4	--	--
Unsound	50.0	96.8	83.4	74.4	98.1	82.2	100.0	85.5
Insects	--	--	--	--	--	5.8	14.4	--
Chalcid	--	--	--	1.3	0.2	2.1	0.3	--
Pitchy	--	--	--	--	--	3.7	14.1	--
Other	--	--	--	73.1	97.9	76.4	85.6	--
Empty	--	--	--	--	97.9	67.3	54.8	--
Whole	--	--	--	--	68.5	--	44.6	--
Broken	--	--	--	--	29.4	--	10.2	--
Aborted	--	--	--	--	--	9.1	30.0	--
Previous year's seed	--	--	--	--	--	--	0.8	--
All	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Basis								
Number of seeds	16	1,097	205	1,243	432	2,466	363	5,822
Number of seed traps	150	150	138	138	53	52	43	--

Table 5.--Condition of Douglas-fir seed falling on clear-cut blocks and under timbered borders, Brush Mountain Unit, Six Rivers National Forest, 1953-1958

Seed condition	1953		1954		1955			1956			1957			1958	All
	Block A	Block D	Block A	Block D	Block A		Block D	Block A		Block D	Block A		Block D	Block A	
	Large 1/	Large	Large	Large	Large	Small 2/	Large	Large	Small	Large	Large	Small	Large	Large	
	Percent														
Sound	15.9	23.4	8.6	12.2	0.7	0.0	1.8	26.6	26.9	20.7	0.2	0.0	1.0	1.0	18.0
Germinated	--	5.9	--	--	0.0	0.0	0.0	16.5	18.7	5.7	0.0	0.0	0.2	0.8	--
Other	--	17.5	--	--	0.7	0.0	1.8	10.1	8.2	15.0	0.2	0.0	0.8	0.2	--
Unsound	3/ 84.1	76.6	91.4	87.8	99.3	100.0	98.2	73.4	73.1	79.3	99.8	100.0	99.0	99.0	82.0
Insects	--	--	--	--	--	--	1.5	2.7	2.7	4.2	13.4	18.5	20.1	15.3	--
Chalcid	--	--	29.4	17.7	0.8	1.4	1.5	1.1	0.9	0.9	0.3	0.7	0.8	3.3	--
Pitchy	--	--	--	--	--	--	0.0	1.6	1.8	3.3	13.1	17.8	19.3	12.0	--
Other	--	--	62.0	70.1	--	98.6	96.7	70.7	70.4	75.1	86.4	81.5	78.9	83.7	--
Empty	--	--	--	--	98.5	98.6	96.7	65.8	65.8	68.3	70.0	74.5	64.7	36.7	--
Whole	--	--	--	--	27.0	30.3	42.0	--	--	--	54.5	53.5	51.8	31.6	--
Broken	--	--	--	--	71.5	68.3	54.7	--	--	--	15.5	21.0	12.9	5.1	--
Aborted	--	--	--	--	--	--	0.0	4.9	4.6	6.8	16.1	7.0	13.7	46.8	--
Previous year's seed	--	--	--	--	--	--	0.0	0.0	0.0	0.0	0.3	0.0	0.5	0.2	--
All	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Basis															
Number of seeds	1,713	984	4,325	3,124	748	142	388	10,058	1,420	8,096	1,259	157	612	393	33,419
Number of seed traps	121	65	120	61	115	98	59	113	91	62	113	92	62	49	--

1/ Seed traps with effective area of 8.2 square feet.
2/ Seed traps with effective area of 1 square foot. Data from both large and small trap samples are listed to show the congruity of sampling results. The performances of large and small seed traps have been compared (Roy, 1959).
3/ Many seed infested with chalcid larvae.

Table 6.--Condition of Douglas-fir seed and fir seed falling on clear-cut blocks and under timbered borders, Mill Creek Unit, Six Rivers National Forest, 1953-1957

Seed condition	Douglas-fir						Fir					
	1953	1954	1955	1956	1957	All	1953	1954	1955	1956	1957	All
	Percent						Percent					
Sound	38.2	6.2	13.2	20.3	0.0	26.0	21.6	0.0	6.8	12.3	0.0	14.6
Germinated	1.6	--	--	2.9	0.0	--	17.2	0.0	--	2.9	0.0	--
Other	36.6	--	--	17.4	0.0	--	4.4	0.0	--	9.4	0.0	--
Unsound	61.8	93.8	86.8	79.7	100.0	74.0	78.4	100.0	93.2	87.7	100.0	85.4
Insects	--	--	--	6.7	8.4	--	--	--	--	--	--	--
Chalcid	--	1.5	0.0	5.0	2.4	--	--	--	0.4	11.4	42.7	--
Pitchy	--	--	--	1.7	6.0	--	--	--	--	--	--	--
Other	--	--	--	73.0	91.6	--	--	--	--	--	57.3	--
Empty	--	--	--	66.0	61.5	--	--	--	--	--	33.3	--
Whole	--	--	60.9	--	55.5	--	--	--	--	--	--	--
Broken	--	--	26.0	--	6.0	--	--	---	--	--	--	--
Aborted	--	--	--	7.0	30.1	--	--	--	--	--	22.7	--
All	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Basis												
Number of seeds	694	65	281	241	83	1,364	906	99	265	766	75	2,111
Number of seed traps	16	23	24	24	23	--	16	23	24	24	23	--

Table 7.--Condition of Douglas-fir seed, Crew Property, vicinity of Salyer, California, 1956

Seed condition	Nov. 3, 1956	Mar. 19, 1957	June 28, 1957	All
	Percent			
Sound				
Germinated	10.6	11.4	0.7	8.6
Other sound	45.3	4.0	16.5	32.6
All sound	55.9	15.4	17.2	41.2
Unsound				
Insect damaged	3.1	4.5	4.0	3.5
Other unsound	41.0	80.1	78.8	55.3
All unsound	44.1	84.6	82.8	58.8
Total	100.0	100.0	100.0	100.0
Basis				
Number of seeds	835	201	297	1,333

Table 8.--Dispersal of sound Douglas-fir seed falling on clear-cut blocks and under timbered borders, Slate Creek Unit, Trinity National Forest, 1954-1957

Year and observation	When position measured in chains from timber edge was --						Basis: sound seed[1]
	Under timber		In cutover				
	2-1	1-0	0-1	1-2	2-3	3-4	
1954:							
Amount of seed--percent	100	71	64	90	40	0	10,619
Sound seed total seed quotient--percent	14	9	15	23	10	2	--
Seed trap observations--number	10	12	11	10	5	3	--
1955:							
Amount of seed--percent	100	61	73	37	0	0	1,448
Sound seed total seed quotient--percent	2	1	2	2	0	0	--
Seed trap observations--number	11	12	10	10	6	4	--
1956:							
Amount of seed--percent	100	83	67	29	40	37	68,543
Sound seed total seed quotient--percent	18	18	21	10	22	26	--
Seed trap observations--number	11	12	10	10	5	4	--
1957:							
Amount of seed--percent	0	0	0	0	0	0	0
Sound seed total seed quotient--percent	0	0	0	0	0	0	--
Seed trap observations--number	8	10	10	9	4	2	--

1/ The number of sound seed per acre falling on the stratum 1 to 2 chains within the timbered border. This statistic was considered to be 100 percent.

Table 9.--Dispersal of sound Douglas-fir seed falling on clear-cut blocks and under timbered borders, Brush Mountain Unit, Six Rivers National Forest, 1953-1958

Year and observation	When position measured in chains from timber edge was --								Basis: sound seed 1/
	Under timber		In cutover						
	2-1	1-0	0-1	1-2	2-3	3-4	4-5	5-6	
1953:									
Amount of seed--percent	100	104	100	66	50	38	3	14	19,115
Sound seed total seed quotient--percent	15	18	20	18	24	27	4	23	--
Seed trap observations--number	23	33	44	22	31	18	9	6	--
1954:									
Amount of seed--percent	100	83	76	64	52	42	46	16	32,551
Sound seed total seed quotient--percent	5	8	13	19	19	14	13	14	--
Seed trap observations--number	23	29	44	21	31	18	10	5	--
1955:									
Amount of seed--percent	0	100	52	76	0	0	0	0	948
Sound seed total seed quotient--percent	0	2	1	4	0	0	0	0	--
Seed trap observations--number	22	28	43	22	30	17	8	4	--
1956:									
Amount of seed--percent	100	69	49	37	20	18	4	8	19,797
Sound seed total seed quotient--percent	25	24	23	24	21	27	13	31	--
Seed trap observations--number	24	29	43	22	31	17	6	3	--
1957:									
Amount of seed--percent	100	130	27	0	39	71	0	0	442
Sound seed total seed quotient--percent	(2/)	1	(2/)	0	1	1	0	0	--
Seed trap observations--number	24	29	44	21	31	17	6	3	--
1958:									
Amount of seed--percent	100	0	139	--	--	--	--	--	442
Sound seed total seed quotient--percent	1	0	2	--	--	--	--	--	--
Seed trap observations--number	12	11	26	0	0	0	0	0	--

1/ The number of sound seed per acre falling on the stratum 1 to 2 chains within the timbered borders (note exception for 1955). This statistic was considered to be 100 percent.

2/ Indicates less than 0.5 percent.

Table 10.--Dispersal of Douglas-fir seed, Slate Creek Unit, Trinity National Forest, and Brush Mountain Unit, Six Rivers National Forest, 1956

Distance in chains from timber edge	Sound seed: Amount per acre	Sound seed: Portion of total seedfall	Unsound seed--Destroyed by insects--: Chalcids	Pitchy	Subtotal	Other: Empty	Aborted	Total unsound	All	Sample size seed traps
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Number
SLATE CREEK UNIT, BLOCKS 1, 4, and 5										
Timber:										
1-2	68,543	18	2	4	6	67	9	82	100	11
0-1	57,079	18	4	3	7	66	9	82	100	12
Total or average	62,562	18	3	3	6	67	9	82	100	23
Cutover:										
0-1	45,663	21	2	5	7	65	7	79	100	10
1-2	19,646	10	1	4	5	74	11	90	100	10
2-3	27,610	22	0	4	4	65	9	78	100	5
3-4	25,221	26	0	1	1	62	11	74	100	4
Total or average	30,760	18	1	4	5	68	9	82	100	29
All	44,826	18	2	4	6	67	9	82	100	52
BRUSH MOUNTAIN UNIT, BLOCKS A and D										
Timber:										
1-2	278,538	25	1	3	4	66	5	75	100	24
0-1	192,797	24	1	3	4	67	5	76	100	29
Total or average	231,623	25	1	3	4	66	5	75	100	53
Cutover:										
0-1	136,941	23	1	2	3	69	5	77	100	43
1-2	101,850	24	1	2	3	66	7	76	100	22
2-3	56,351	21	1	1	2	67	10	79	100	31
3-4	50,286	27	1	2	3	63	7	73	100	17
4-5	12,389	13	3	2	5	70	12	87	100	6
5-6	21,239	31	2	3	5	59	5	69	100	3
Total or average	89,090	23	1	2	3	67	7	77	100	122
All	132,257	24	1	2	3	67	6	76	100	175